NOTES AND COMMENTS

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RESOURCE DEPENDENT LARVIPOSITION BEHAVIOR OF A PITCHER PLANT FLESH FLY, *FLETCHERIMYIA FLETCHERI* (ALDRICH) (DIPTERA: SARCOPHAGIDAE)

Several studies have focused on the pitcher plant flesh fly, *Fletcherimyia fletcheri* (Aldrich), due to its unique biology (Fish and Hall, 1978; Forsyth and Robertson, 1975; Judd, 1959; Lloyd, 1942; Swales, 1969, 1972). In brief, what is known is that *F. fletcheri* females larviposit first instar larvae, usually singly, into the newest leaves of the northern pitcher plant, *Sarracenia purpurea* L., starting at the beginning of June. *Fletcherimyia fletcheri* larvae feed on dead insects floating at the water-air interface in pitchers. The larvae are territorial and attempt to kill each other during encounters, usually resulting in a distribution of one larva per pitcher. Larval development, consisting of three instars, is completed within the leaves of the northern pitcher plant. At the conclusion of larval development, *F. fletcheri* larvae crawl from the leaves and pupate in the sphagnum moss below pitcher plants (Forsyth and Robertson, 1975).

I tested whether *F. fletcheri* larviposition choices were affected by the presence and quality of prey in leaves of *S. purpurea.* To meet this objective, whole prey (house flies), crushed prey (crushed house flies), or no additional prey were added to new pitchers in the field, and subsequent occupation of pitchers by *F. fletcheri* was censused.

MATERIALS AND METHODS

Study site. This experiment was conducted from 25 July to 1 August 1996 at Brighton Bog (44°26′50″N, 74°12′52″W) in the Adirondack Preserve of New York State just north of Paul Smiths in Franklin County. Brighton Bog is a large quaking bog (approximately 2 ha in size) with an open pond at the northwestern edge. The bog mat consists primarily of *Sphagnum* sp. moss and does not support the growth of tall vegetation. The bog is within a forest dominated by white pine (*Pinus strobus* L.), tamarack (*Larix laricina* (Duroi)), and occasional deciduous trees. Plants found growing at the edges of the bog during different parts of the season included leather leaf (*Chamaedaphne calyculata* (L.)), sheep laurel (*Kalmia augustifolia* L.), labrador tea (*Ledum groenlandicum* Oeder), and bog rosemary (*Andromeda glaucophylla* Link). In addition, cotton grass (*Eriophorum polystachion* L.) flourished in the center of the bog during late summer and into early fall. *Sarracenia purpurea* L. plants were the most abundant during this study at the perimeter of the bog.

Prey addition experiment. The perimeter of Brighton Bog containing the highest densities of *S. purpurea* plants was subdivided into eighteen locations. Seven out of the eighteen locations were chosen randomly to set up the prey addition experiment.

On 25 July, three pitcher plants (closely situated to each other) at each of the seven locations were selected, and the contents of the newest pitcher on each plant (determined by choosing the pitcher originating from the center of a leaf whorl, as in Fish and Hall, 1978) were removed using a suction device consisting of a plastic 15 ml elongate tip syringe (with tip removed) with an attached piece of tygon tubing (see Rango, 1999 for details). The newest pitcher on each plant was used to minimize age differences among pitchers. Individual pitchers at each location were filled with distilled water and then randomly assigned to one of the following prey addition treatments: addition of (1) 10 whole, freeze-killed *Musca domestica* L. house flies every other day from 25–31 July, (2) 10 crushed, freeze-killed *M. domestica* house flies every other day from 25–31 July, and (3) no *M. domestica* (control). For treatment 2, forceps were used to crush house flies so that body contents were more readily available for consumption by *F. fletcheri* larvae. Crushed house flies were hypothesized to be higher quality prey than whole house flies because they could be more easily eaten by flesh fly larvae. On 1 August, all contents of each pitcher were again removed using the suction device, larvae present in pitchers were counted, and contents were then poured back into pitchers. A sample of the larvae was retained so that identifications could be made later in the laboratory. Larvae were identified as *F. fletcheri* using Courtney et al., 1996.

A preliminary survey of *S. purpurea* leaves on Brighton Bog showed that 10.38 ± 8.35 (mean ± SD) prey items were captured by the newest leaves on 24 pitcher plants over a two week period (29 June–12 July 1996). Thus, experimental pitchers with supplemented house flies had greatly enhanced quantities of prey over natural levels.

Statistical analyses. The data collected, numbers of flesh fly larvae in experimental pitchers, were transformed using the Freeman and Tukey transformation, $\sqrt{\text{count}} + \sqrt{\text{count} + 1}$ (as cited by Sokal and Rohlf, 1995), to normalize the data and stabilize variances in statistical tests. The Freeman and Tukey transformation is appropriate for data that consists of counts including zero values. A one-way ANOVA performed on transformed numbers of flesh fly larvae was used to determine whether the number of larvae surviving in pitchers (arranged in a randomized block design) was affected by the prey addition treatments. *Post hoc* contrasts were used to distinguish the source of differences among prey addition treatments.

RESULTS

Higher numbers of flesh flies were found in pitchers with added prey than with no additional prey (control) at the end of the eight day prey addition experiment (Fig. 1; Table 1; control < whole prey, crushed prey; *post hoc* comparison $F_{1,12} = 7.35$, $P = 0.02$). This difference in larval flesh fly density among prey addition treatments was visually distinct. Some pitchers with added prey were inhabited by five flesh fly larvae of various sizes, whereas control pitchers never contained more than one larva. Numbers of flesh flies in pitchers were not different between whole prey and crushed prey addition treatments (*post hoc* comparison $F_{1,12} = 0.73$, $P = 0.41$).

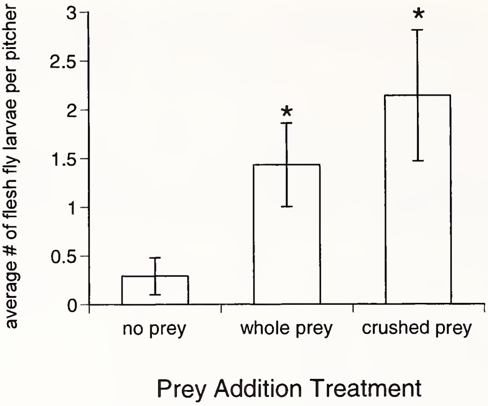

Fig. 1. Mean number (± 1 SE) of flesh fly larvae in no additional prey (control), whole prey, and crushed prey treatment pitchers sampled at the end of an eight day prey addition experiment (25 July–1 August 1996) performed on Brighton Bog, Paul Smiths, NY. Note: *indicates significant difference from control.

DISCUSSION

The higher numbers of flesh flies in pitchers supplemented with prey compared to no additional prey suggests that *F. fletcheri* show a resource dependent larviposition behavior. Larvipositing females may preferentially cue in on pitchers with high prey levels. Habitat assessment during larviposition or oviposition is common among Diptera. For example, mosquitoes make oviposition choices using visual, tactile, chemotactile, and olfactory cues (Bentley and Day, 1989). In this experiment, pitchers with the highest numbers of flesh fly larvae contained several decomposing house flies floating on the surface of the water giving off a putrid stench. At least one other species of sarcophagid (*Sarcophaga* (*Neobellieria*) *bullata* Parker) is known to orient olfactorily to oviposition sites (Cole Gilbert, pers. comm.). Females of *F. fletcheri* may be attracted to the smell of decomposing insect prey (olfactory cue) or chemical constituents in the pitcher fluid associated with high levels of decomposition (chemotactile cue).

The quality of prey in pitchers, at least in terms of whole prey versus crushed prey, did not affect how many *F. fletcheri* larvae occupied pitchers. Crushed house

Table 1. One-way ANOVA comparing $\sqrt{\text{count}} + \sqrt{\text{count} + 1}$ transformed numbers of flesh fly larvae occuring in pitchers receiving different prey treatments (addition of whole prey, crushed prey or no prey (control)) sampled at the end of an eight day prey addition experiment (25 July–1 August 1996). Treatments were set up in a randomized block design across Brighton Bog, Paul Smiths, NY

Source	Sum of Squares	Degrees of Freedom	F Test	P value
Block	5.248	6	0.751	0.621
Prey Treatment	9.423	2	4.043	0.045
Error	13.984	12		

flies may not be perceived as different from whole house flies by larvipositing *F. fletcheri* females. The mere presence of abundant prey in pitchers, regardless of condition (i.e., more or less accessible to feeding larvae), may be enough to stimulate larviposition by *F. fletcheri* females. However, experiments with varying prey types and quantities would be necessary to test this hypothesis.

A resource dependent larviposition behavior may be evolutionarily advantageous to *F. fletcheri.* In particular, the aquatic microcosms supported by *S. purpurea* leaves have been shown to be resource limiting to the larvae of both the pitcher plant mosquito, *Wyeomyia smithii* (Coquillett) (Diptera: Culicidae), and the pitcher plant midge, *Metriocnemus knabi* (Coquillett) (Diptera: Chironomidae) (Bradshaw, 1983; Farkas and Brust, 1985; Heard, 1994; Istock et al., 1975). In addition, studies have shown that more than one flesh fly can exist in the same artificial microcosm only at high food levels, suggesting that *F. fletcheri* larvae may also be resource limited in nature. Consequently, a resource dependent larviposition behavior may help ensure that *F. fletcheri* larvae are placed into habitats with the highest food levels leading to maximum larval survival.—*Jessamy J. Rango, Department of Entomology, Cornell University, Ithaca, New York 14853-0901; present address: Department of Biology, P.O. Box 871501, Arizona State University, Tempe, AZ 85287-1501.*

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NEST MATERIAL REUSE BY *PARACHARTERGUS* R. VON IHERING (HYMENOPTERA: VESPIDAE)

Social wasps (Vespidae) construct their nests of vegetable fiber (a few tropical species utilize mud). Using water to soften the fibers at the source, foragers use their mandibles to scrape up a wad of wet pulp, which is carried back to the nest. The mass is mixed with a salivary adhesive and formed into the cells and envelope. The adhesive secretion forms a thin matrix that binds the fibers together and confers a water repellency to the finished carton.

Nest construction and maintenance is dangerous since it requires numerous trips of workers for material location and transportation (Jeanne, 1986). Nevertheless few species reprocess nest material from one part of the nest for use in other parts during normal nest expansion. *Belonogaster* and *Vespula* spp. tear down inner layers of envelope for use in constructing new cells (Gadagkar, 1991, Greene 1991; Wenzel, 1991). Nest material reuse has also been found in several *Polistes* species as *P. annularis* (L. 1763), *P. metricus* Say, 1831 in the United States, *P. olivaceus* (Degeer, 1773) in Madagascar, *P. dominulus* (Christ, 1791) in Europe (Wenzel, pers. comm).

However, to date few species have been reported to salvage material from an